REMARKS

Claims 1-23 are pending in this application. Claims 1-23 are rejected. Claims 1, 8 and 18 have been amended. No new matter has been added. It is respectfully submitted that the pending claims define allowable subject matter.

Claims 1-7, 18-19 and 23 have been rejected under 35 U.S.C. § 102(b) as being anticipated by Clark (U.S. Patent 6,139,500). Applicants respectfully traverse this rejection.

Clark describes a method and apparatus for 3D cardiac ultrasound imaging wherein scanning in a slow scan direction may be controlled by starting scanning at uniformly-spaced time intervals relative to the patient's cardiac cycle (abstract). Scan paths are slanted at an intermediate angle between the vertical and horizontal in time/space diagrams (column 7, lines 23-26). The scan paths are aliased into an equivalent-time cardiac cycle using an ECG trigger (column 7, lines 35-36). Correct reconstruction of the acquired data into images of the volume of interest requires keeping a record of the time of every ECG trigger and the time of the start of each scan in the slow scan direction, either relative to each other or relative to a time reference, such as the start of acquisition. This information may be recorded in various equivalent ways. The acquired image data may be resorted into a more easily accessible order as it is being acquired or as part of scan conversion processing (column 9, lines 21-29).

Claim 1, as amended, recites a method of processing a volumetric scan comprising "identifying a time interval of a periodic movement of said periodically moving object within said volumetric scan based on movement information determined from scan data acquired by the volumetric scan." Clark fails to describe or suggest such a method.

In contrast to claim 1, as amended, Clark does not identify a time interval of periodic movement of a periodically moving object within a volumetric scan based on movement information determined from the scan data. Clark uses ECG trigger information from an external source to determine a time interval. Clark fails to describe or suggest using the scan data in any way to identify a time interval. Accordingly, Applicants submit that for at least the reasons set forth above that claim 1 is patentable over Clark.

Claims 2-7 depend from independent claim 1. When the recitations of these claims are considered in combination with the recitations of claim 1, Applicants submit that these dependent claims are likewise patentable over Clark for at least the same reasons set forth above.

Claim 18, as amended, recites a apparatus for acquiring a volumetric scan comprising "a processor for processing said series of adjacent scan planes, said processor identifying a time interval based on said periodically moving object based on movement information determined from said series of adjacent scan planes, said processor rearranging said series of adjacent scan planes based on said time interval." Clark fails to describe or suggest such an apparatus.

As discussed above with reference to claim 1, Clark fails to describe or suggest a processor identifying a time interval based on a periodically moving object based on movement information determined from a series of adjacent scan planes. Clark describes a system that uses ECG trigger information from an external source to determine a time interval. Accordingly, Applicants submit that for at least the reasons set forth above that claim 18 is patentable over Clark.

Claims 19 and 23 depend from independent claim 18. When the recitations of these claims are considered in combination with the recitations of claim 18, Applicants submit that these dependent claims are likewise patentable over Clark for at least the same reasons set forth above.

Claims 1-8, 10-12, 14-20 and 23 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Clark (U.S. Patent 6,139,500) in view of Pang et al. (U.S. Patent 6,190,321), alone or further in view of (a) Powers et al. (U.S. Patent 5,099,847) and Urbano et al. (U.S. Patent 5,976,088) or (b) Sheehan et al. (U.S. Patent 5,570,430). Applicants respectfully traverse this rejection.

Clark is described above.

Pang et al. describes a medical diagnostic ultrasonic image processing method that estimates motion between first and second composite ultrasonic images that include both B-mode and Color Doppler information (abstract). A motion estimator 34 accepts as an input B-mode images from a B-mode extractor 32 and compares selected B-mode images to determine motion therebetween. The motion estimator 34 can use any of a variety of techniques for estimating the relative motion between selected images, such as those described in the patent documents referenced in the background portion of the specification (column 4, lines 49-55). Thus, original Color Doppler values are recovered from a composite image. The Color Doppler values can be used to detect a selected phase of the cardiac cycle, thereby eliminating the need for EKG triggering devices when single-phased images are acquired (column 9, lines 25-28).

Powers et al. describes a high frame rate ultrasound system wherein frames are interleaved from any number of consecutive cardiac cycles. Specifically, if N is the number of heart cycles that are to be interleaved to produce a single display sequence, then the first series of frames may be acquired at times 0, NT, 2NT, etc.; the second series of frames may be acquired at times T, (N+1)T, (2N+1)T, etc.; the third sequence of frames may be acquired at times 2T, (N+2)T, (2N+2)T, etc. As a result of such interleaving, the acquisition frame rate of 1/(NT) will be increased by a factor of N, to produce a display frame rate of 1/T (column 3, lines 22-33). An ECG unit 40 is connected to the subject under investigation and processes the ECG signal, and produces a series of trigger signals that are received by a control unit 26 of the ultrasound system (column 4, lines 18-29). A frame time is determined for each frame, the frame time being the time from the preceding trigger signal to the frame's acquisition time (column 3, lines 39-42).

Powers et al. further describes that the trigger signal could be derived from a pressure cuff attached to the subject, or could be based upon the maximum Doppler shift or the maximum brightness of an image feature, as measured by the ultrasound system. The latter technique may be especially useful for fetal imaging (column 5, lines 25-34).

Urbano et al. describes an ultrasound imaging system having a QRS trigger detection device. The system 156 includes an image frame acquisition device 134, image frame memory 138 and frame correlation processor 140. The frame correlation processor 140 receives a stream of successively acquired image frames, consisting of collection image frames, such as full-resolution frames 152, or combinations of collection image frames and interrogation frames. The frame correlation processor 140 determines the difference between the current image frame and at least one preceding image frame and outputs a frame correlation coefficient based upon the difference. The correlation coefficients output from the frame correlation processor 140 are input to a QRS trigger detector 158 which determines the QRS trigger therefrom. The time interval associated with the QRS trigger is identified as the instance of time when the frame correlation coefficient falls below a predetermined value, or instance of time when the rate of change of the frame correlation coefficient becomes greater than a predetermined value (column 16, lines 4-28). Further, the QRS trigger may be used to calculate the heart rate, or to control conventional acquisition equipment which currently requires a QRS trigger obtained from a conventional physiological monitor. The QRS trigger detector 158 may use the mean difference values instead of the frame correlation coefficients (column 16, lines 43-48). The mean difference values of the start of systole reach a peak, thereby providing an identifiable indicator of this stage in the heart cycle (column 16, lines 56-59).

Sheehan et al. describes a method for determining the contour of an in vivo organ using multiple image frames of the organ wherein the LV should have its smallest cross-sectional area at the end of systole. Also, the end systole image frame often corresponds to the image frame with the smallest area of relatively bright pixels within the region of interest. Therefore, histograms are produced of the pixels lying within the region of interest for each image frame. These histograms include separate totals for the number of pixels having the same gray scale value for each different gray scale value within the region of interest. The region of interest histogram of each image frame is then normalized for the variation in relative gray scale values between image frames, using the normalization factors from block 125. Each normalized region of interest histogram is used as a feature vector (different than

the feature vectors derived from the pixel vectors) in a classifier 128, which determines the end systole image frame (column 10, lines 28-43).

Claim 1, as amended, recites a method of processing a volumetric scan comprising "identifying a time interval of a periodic movement of said periodically moving object within said volumetric scan based on movement information determined from scan data acquired by the volumetric scan; and rearranging said volumetric scan based on said time interval." The prior art of record fails to describe or suggest such a method.

As discussed above, Clark fails to describe or suggest using the scan data to determine movement information to identify a time interval for use in rearranging volumetric scan data. Pang et al. describes extracting images from a composite image, and in particular extracting B-mode and Color Doppler images (abstract). The extracted images are used to form a multi-frame image that includes Color Doppler image data from a composite image from a single phase of a cardiac cycle. Color Doppler values are used to detect a selected phase of the cardiac cycle. However, in contrast to claim 1, Pang et al. fails to describe or suggest rearranging a volumetric scan based on movement information. Pang et al. merely describes using B-mode and Color Doppler frames to form a multi-frame image. Pang et al. does not describe or suggest any rearranging of a volumetric scan and further, does not use movement information from the scan data. Accordingly, Applicants submit that for at least the reasons set forth above that claim 1 is patentable over Clark in view of Pang et al.

Further, Powers et al. describes an interleaving process that uses to produce a single display sequence. The maximum brightness of an image feature may be used to determine a trigger signal. Additionally, Urbano et al. describes using a QRS trigger to determine when a frame correlation coefficient falls below a predetermined threshold. A plurality of frames of data are then provided in an image loop. Finally, Sheehan et al. uses gray scale values of normalized regions of interest of a histogram of each image frame to determine an end systole image frame. The sequence of image frames is then used to determine a contour of a left ventricle.

In contrast, claim 1 recites rearranging a volumetric scan, not frames of data, and further, based on movement information from the scan data. These references simply do not describe or suggest rearranging a volumetric scan. Further, the references do not describe or suggest using movement information from the scan data, but instead, use other trigger information. Accordingly, Applicants submit that for at least the reasons set forth above that claim 1 is patentable over Clark in view of Pang et al. and further in view of (a) Powers et al. and Urbano et al. or (b) Sheehan et al.

Claims 2-7 depend from independent claim 1. When the recitations of these claims are considered in combination with the recitations of claim 1, Applicants submit that these dependent claims are likewise patentable over these references for at least the same reasons set forth above.

Claim 8, as amended, recites a method of acquiring a diagnostic image comprising "identifying at least one common coordinate point of interest within each of said series of scan planes" and "comparing intensity values of said at least one common coordinate point of interest between said series of scan planes; identifying at least two intensity values within said series of scan planes based on a result of said comparing step; and rearranging said series of scan planes based on said at least two intensity values." The prior art of record fails to describe or suggest such a method.

The references cited in this 103 rejection fail to describe or suggest identifying at least one common coordinate point of interest within each of a series of scan planes. In contrast, the references merely describe using values and thresholds to determine certain events of interest or ends of frames. No where in any of these references is described or suggested a common coordinate point in each of a series of scan planes. Accordingly, Applicants submit that for at least the reasons set forth above that claim 8 is patentable over Clark in view of Pang et al. or Clark in view of Pang et al. and further in view of (a) Powers et al. and Urbano et al. or (b) Sheehan et al.

Claims 10-12 and 14-17 depend from independent claim 8. When the recitations of these claims are considered in combination with the recitations of claim 8, Applicants submit

that these dependent claims are likewise patentable over these references for at least the same reasons set forth above.

Claim 18, as amended, recites a apparatus for acquiring a volumetric scan comprising "a processor for processing said series of adjacent scan planes, said processor identifying a time interval based on said periodically moving object based on movement information determined from said series of adjacent scan planes, said processor rearranging said series of adjacent scan planes based on said time interval." The prior art of record fails to describe or suggest such an apparatus.

As discussed above with reference to claim 1, claim 18 likewise recites rearranging adjacent scan planes based on movement information from the scan planes. These references simply do not describe or suggest rearranging scan planes based on movement information from the scan planes. Accordingly, Applicants submit that for at least the reasons set forth above claim 18 is patentable over Clark in view of Pang et al. or Clark in view of Pang et al. and further in view of (a) Powers et al. and Urbano et al. or (b) Sheehan et al.

Claims 19, 20 and 23 depend from independent claim 18. When the recitations of these claims are considered in combination with the recitations of claim 18, Applicants submit that these dependent claims are likewise patentable over these references for at least the same reasons set forth above.

Claims 9, 13 and 21-22 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the references as applied to claim 18 and further in view of Bonnefous (U.S. Patent 6,647,135). Applicants respectfully traverse this rejection.

Bonnefous describes an ultrasonic image processing method and system wherein a first imaging technique called CVI (from Color-coded Velocity Imaging) measures blood flow velocity directly by using time domain processing. CVI tracks individual clusters of blood cells using ultrasound to measure the distance and the time traveled. CVI is based on the principle of signature recognition. In a time domain correlation process, a first echo is stored in a digital memory. The shape of signal traces the relative position of blood cells, which is called ultrasound signature of the cluster. Some microseconds later, a second echo

signal is stored. A computing system analyzes the two signal signatures by time shifting these two signatures until they match perfectly. This time shift is directly related to the distance the blood cells have moved, using the speed of sound in tissue. Blood-cell velocity is obtained by dividing this measured distance by the time between the two corresponding ultrasound pulses. It is to be noted that CVI measures peak velocities. Correction of the cosine angle between the vessel axis and the ultrasound beam is performed and the velocity computations are coded in shades of red and blue (column 4, lines 50-63) In another embodiment, based on the Doppler technique, the blood flow estimation stage 110 processes Doppler echo signals issued by stage 20 of the ultrasonic sub-system 1, to obtain Doppler shift characteristics such as frequency corresponding to velocity and Doppler power corresponding to intensity. A Doppler processor processes an ensemble of two or more received echo sequences from a same spatial location of the artery and determines the Doppler phase or frequency shift (column 5, lines 52-60).

Applicants submit that even from a cursory reading of this reference, it fails to make up for the deficiencies of the references as applied to claim 18 above. Bonnefous uses time shift information to determine timing information that is different from the moving object repeating a cycle of movement and the periodically moving object as recited in claims 8 and 18, respectively. Thus, when the recitations of claims 9 and 13 are considered in combination with the recitations of claim 8, and the recitation of claims 21 and 22 are considered in combination with the recitations of claim 18, Applicants submit that these dependent claims are likewise patentable over these references for at least the same reasons set forth above.

Claims 8, 10, 12 and 15-17 have been rejected under 35 U.S.C. § 102(b) as being anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Powers (U.S. Patent 5,099,847). Applicants respectfully traverse this rejection.

As discussed above, Powers fails to describe or suggest identifying a common coordinate point of interest within each of a series of scan planes as recited in claim 8. Thus, and for at least the reasons discussed above, Applicants submit that claim 8 is patentable over Powers et al.

Claims 10, 12 and 15-17 depend from independent claim 8. When the recitations of these claims are considered in combination with the recitations of claim 8, Applicants submit that these dependent claims are likewise patentable over Powers et al. for at least the same reasons set forth above.

Claims 9 and 13 have been rejected under 35 U.S.C. § 103(a) as being unpatentable over Powers as applied to claim 8 and further in view of obvious Bonnefous. Applicants respectfully traverse this rejection.

Applicants submit that even from a cursory reading of this reference, it fails to make up for the deficiencies of the references as applied to claim 8 above. Bonnefous uses time shift information to determine timing information different from the moving object repeating a cycle of movement as recited in claim 8. Thus, when the recitations of claims 9 and 13 are considered in combination with the recitations of claim 8, Applicants submit that these dependent claims are likewise patentable over these references for at least the same reasons set forth above.

Thus, for at least the reasons set forth above, Applicants respectfully request that the 35 U.S.C. § 102 and § 103 rejections of claims 1-23 be withdrawn.

In view of the foregoing amendments and remarks, it is respectfully submitted that the prior art fails to teach or suggest the claimed invention and all of the pending claims in this application are believed to be in condition for allowance. Reconsideration and favorable action is respectfully solicited. Should anything remain in order to place the present application in condition for allowance, the Examiner is kindly invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,

Evan Reno Sotiriou
Registration No. 46,247
ARMSTRONG TEASDALE LLP
One Metropolitan Square, Suite 2600
St. Louis, MO 63102-2740
(314) 621-5070